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NASA Publications Guide for Authors

National Aeronautics and
Space Administration

November 1999

The NASA STI Program Office ... in Profile

Since its founding, NASA has been dedicated to the advancement of aeronautics and space science. The NASA Scientific and Technical Information (STI) Program Office plays a key part in helping NASA maintain this important role.

The NASA STI Program Office is operated by Langley Research Center, the lead center for NASA's scientific and technical information. The NASA STI Program Office provides access to the NASA STI Database, the largest collection of aeronautical and space science STI in the world. The Program Office is also NASA's institutional mechanism for disseminating the results of its research and development activities. These results are published by NASA in the NASA STI Report Series, which includes the following report types:

- **TECHNICAL PUBLICATION.** Reports of completed research or a major significant phase of research that present the results of NASA programs and include extensive data or theoretical analysis. Includes compilations of significant scientific and technical data and information deemed to be of continuing reference value. NASA counterpart of peer-reviewed formal professional papers, but having less stringent limitations on manuscript length and extent of graphic presentations.
- **TECHNICAL MEMORANDUM.** Scientific and technical findings that are preliminary or of specialized interest, e.g., quick release reports, working papers, and bibliographies that contain minimal annotation. Does not contain extensive analysis.
- **CONTRACTOR REPORT.** Scientific and technical findings by NASA-sponsored contractors and grantees.

- **CONFERENCE PUBLICATION.** Collected papers from scientific and technical conferences, symposia, seminars, or other meetings sponsored or co-sponsored by NASA.
- **SPECIAL PUBLICATION.** Scientific, technical, or historical information from NASA programs, projects, and missions, often concerned with subjects having substantial public interest.
- **TECHNICAL TRANSLATION.** English-language translations of foreign scientific and technical material pertinent to NASA's mission.

Specialized services that complement the STI Program Office's diverse offerings include creating custom thesauri, building customized databases, organizing and publishing research results ... even providing videos.

For more information about the NASA STI Program Office, see the following:

- Access the NASA STI Program Home Page at <http://www.sti.nasa.gov>
- E-mail your question via the Internet to help@sti.nasa.gov
- Fax your question to the NASA STI Help Desk at (301) 621-0134
- Phone the NASA STI Help Desk at (301) 621-0390
- Write to:
NASA STI Help Desk
NASA Center for AeroSpace Information
7121 Standard Drive
Hanover, MD 21076-1320

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Available from:

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Hanover, MD 21076-1320
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National Technical Information Service (NTIS)
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Springfield, VA 22161-2171
(703) 605-6000

This report is also available in electronic form at URL <http://www.sti.nasa.gov/> and
<http://techreports.larc.nasa.gov/cgi.bin/ntis>

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1 Introduction

Publication of scientific and technical information (STI) is one of the responsibilities of NASA as a Government Agency. The National Aeronautics and Space Act of 1958 established a requirement for NASA to provide "the widest practicable and appropriate dissemination of information concerning its activities and the results thereof." Persons engaged in NASA-funded or NASA-sponsored research and development and related efforts are therefore required to publish the results of their work in the NASA STI series or through other externally accessible channels.

An Agency-wide committee of publications professionals prepared the standards and conventions presented in this guide for authors. The committee began with NASA SP-7047, *NASA Publications Guide* (ref. 1), and revised it based on requirements in NPG 2200.2A, *Guidelines for Documentation, Approval, and Dissemination of NASA Scientific and Technical Information* (ref. 2) and current professional publications standards.

Section 2 of this guide presents descriptions of each type of report in the NASA STI Report Series and briefly discusses the applicable production methods and appropriate dissemination of these reports. In a subsection on selection of the appropriate publication channels, it also suggests other avenues for releasing STI. Section 3 discusses professional and ethical concerns, such as authorship, contributors, and copyright. Section 4 provides recommended standards for document format, makeup, and organization. Section 5 presents miscellaneous preparation concerns.

Contact the NASA STI Lead Center or your center publications office to discuss specific preparation, production, review and approval, printing or reproduction, distribution, and scheduling requirements for your proposed publications. Additional publishing guidance may be found on the STI webpage at uniform resource locator (URL) <http://www.sti.nasa.gov/>.

2 General Information and Requirements

2.1 Selection of Publication Channel

Various external publication channels in addition to the NASA STI Report Series are available to you. Non-NASA channels include oral presentations, periodicals, books, or proceedings volumes by non-NASA publishers. All releases are subject to approval as prescribed in reference 2 and the originating NASA center approval procedures.

2.1.1 NASA STI Report Series

The NASA STI Report Series is a channel for publication of NASA scientific and technical information. Make the initial selection of the appropriate report series type in consultation with the NASA STI Lead Center or the publications office of your originating center, based on the content of the document and the intended readership. The selection of the report series type is subject to review as part of the originating center's review process. (See section 2.2.)

2.1.2 Presentations at Professional Meetings

Presentations at society meetings and other professional gatherings ensure the timely dissemination of NASA scientific and technical findings to appropriate audiences. You may obtain

TM (Technical Memorandum) numbers for your presentations: this allows you to distribute copies to attendees and ensures that the paper is included in the NASA STI Database. Such TM's may be published in proceedings published by the meeting sponsor.

2.1.3 Non-NASA Publications

Appropriate non-NASA publications for NASA STI include professional society journals, trade journals, and similar periodicals produced by professional, technical, or academic organizations. Proceedings of scientific and technical conferences, symposia, and workshops are also distribution channels for NASA STI. Manuscripts submitted to such channels for publication must have NASA prior approval.

2.1.4 Duplicate Publication

Publication of STI through non-NASA channels does not preclude the publication of equivalent information by NASA. For example, significant findings could be reported in a journal and more detailed documentation of these findings could then be published as a NASA TP (Technical Publication). However, you should not publish identical material through different channels, with the following exceptions for the TM series:

- Preprints of presentations at professional meetings
- Preprints of journal articles

2.2 NASA STI Report Series

The benefits of publishing and disseminating your document in the NASA STI Report Series are given in section 2.5. The NASA STI Report Series comprises six types of technical reports. The six report types (Technical Publication, Technical Memorandum, Contractor Report, Conference Publication, Special Publication, and Technical Translation) are described in this guide. The appropriate NASA STI Report Series type is selected according to document content and the needs of the readership. Make the selection based on the descriptions provided herein, with assistance from your center publications office, if needed. Appendix A is a quick-reference tool for matching manuscript contents with the appropriate STI report type and distribution. The selection is subject to approval as part of the STI Lead Center or originating center's review process.

When a document is approved for publication, the publications office at the originating center obtains a report number from the NASA Center for Aerospace Information (CASI). The NASA numbering scheme has been changed to meet ANSI (American National Standards Institute) and year 2000 standards and now fits the format: NASA/TM—1999-123456, where TM is report series type. All STI that is published or released via any media must have a signed NASA Form 1676 (NASA Scientific and Technical Document Availability Authorization (DAA)) on file at the originating center. A copy of NASA Form 1676 can be located at URL <http://www.sti.nasa.gov/daa.htm>.

You may choose the type of dissemination that your NASA STI Report Series document receives, except in the case of CR's. Section 2.5 explains your dissemination options. For CR's, you should use the following guidance:

- Wider dissemination (called standard distribution in section 2.5.1.1) for documents that contain findings of completed significant scientific and technical work
- Narrower dissemination (called nonstandard distribution in section 2.5.1.2) for those documents that are preliminary or of interest to a limited number of people

2.2.1 Technical Publication

The Technical Publication (TP) series consists of reports of completed research or of a significant phase of research that presents the results of NASA programs. TP's usually include extensive data or theoretical analysis, but they may be compilations of significant scientific and technical data or information deemed to be of continuing value. TP's are the NASA counterpart to peer-reviewed formal professional papers but have less stringent limitations on manuscript length and extent of graphics presentation. Technical review of a TP is done by a committee of peers or an expert single reviewer. In addition to reports documenting research, the types of documents assigned to this series include the following:

- Bibliographies with abstracts and/or extensive annotation
- Technical handbooks, critical tables, and extensive-use data compilations
- Design standards
- Scientific and technical textbooks and manuals
- State-of-the-art summaries, including critical reviews or surveys of a body of scientific or technical literature
- Technical reports or monographs that provide complete and comprehensive treatment of significant contributions to scientific and technical knowledge or a critical evaluation of selected, previously published research

2.2.2 Technical Memorandum

The Technical Memorandum (TM) series records scientific and technical findings that are preliminary or of interest to a limited number of readers, such as quick-release reports, working papers, and bibliographies that contain minimal annotation. TM's do not contain extensive analysis. Technical review is the responsibility of the author's technical management. Peer review is not required for a TM. Types of documents assigned to this series include the following:

- Working papers for professional peers beyond the basic work group
- Individual papers prepared for presentation at or preprints for professional meetings or symposia, which may or may not be published later in proceedings volumes (such as a NASA CP) or journals
- Collections of proceedings of professional meetings or symposia sponsored or cosponsored by NASA. TM's are normally preliminary papers, abstracts, or viewgraphs. (See also section 2.2.4.)
- Theses or dissertations that relate to Agency work, written by NASA employees only
- Bibliographies that present listings of STI literature, without evaluation, written by NASA employees, contractors, and grantees
- Abbreviated conference records, such as figure preprints or abstracts and figures only

2.2.3 Contractor Report

The Contractor Report (CR) series consists of reports of scientific and technical findings obtained from NASA-sponsored research. CR's containing findings of completed or significant scientific and technical work comparable to a TM are given standard distribution (see section 2.5.1.1). CR's that are preliminary or of interest to a limited number of people receive nonstandard distribution (see section 2.4.1.2). Reports prepared by contractors or grantees are processed into the NASA STI Report Series only after the contract technical monitor has approved the report as an acceptable deliverable under the terms of the contract or grant. Review of this series document is by the NASA contract technical monitor, contracting officer's technical representative, and/or other NASA technical reviewer.

Although final versions of these reports are usually published as CR's, a report authored by a contractor or grantee may be selected by the cognizant NASA monitoring office for publication in another NASA Report Series. Such reports must meet all criteria for the selected series and must be reviewed and approved at the level required for that series.

Contractor- and grantee-produced final reports should contain appropriate acknowledgment of NASA support and identify the contractor grant under which the work was conducted.

2.2.4 Conference Publication

The Conference Publication (CP) series consists of collections of papers (not just abstracts and viewgraphs) from NASA-sponsored scientific and technical conferences, symposia, seminars, or other meetings sponsored or cosponsored by NASA. (A preprint may be included in this series if it will not be published later as a collection of full papers.)

2.2.5 Special Publication

The Special Publication (SP) series records scientific, technical, or historical information from NASA programs, projects, and missions, often concerned with subjects having substantial general public interest. Professional review of this series is controlled by the originating NASA Headquarters Office or NASA center. The types of documents assigned to this series include

- Scientific summaries of mission results
- Atlases of scientific imagery
- Selected outlook studies, comprehensive program descriptions, and retrospective assessments
- Contractor or grantee results and findings of general interest to a wide public audience
- Histories and chronologies
- Management publications, such as those that document requirements, plans, theories, or techniques for management or administration of NASA-sponsored scientific and technical work; such documents can include NASA projects or programs that have application to more than one NASA center, to other government agencies, or to partnerships with industrial or international organizations. (Although reports discussing methods of scheduling, funding, or staffing may be included, reports that carry specific costs or labor figures are not appropriate to this series.)
- Regularly published abstracts, continuing bibliographies, indexes, publication guides, and announcement journals

2.2.6 Technical Translation

The Technical Translation (TT) series consists of English-language translations of foreign-language scientific and technical material pertinent to NASA's mission. A translation of material protected by copyright is a derivative work, the distribution of which is constrained by international copyright law. Translated documents are assigned report numbers and are accessioned into the NASA STI database by NASA CASI; however, distribution is restricted to the U.S. Government.

2.3 Production Methods

Publications included in the NASA STI Report Series shall be professional in appearance and capable of electronic transmission. Instructions in appendix B, Author Checklist To Publish Documents in the NASA STI Report Series, and appendix C, Publications Review Checklist, provide general guidelines for the publication and approval process. For specific instructions, contact your center publications office.

Nonprint methods, such as microphotography, video, and electronic media (e.g., Internet and CD-ROM) may be used as the primary dissemination method or may accompany or supplement printed NASA STI. See section 2.4 for factors to be considered in electronic dissemination. Nonprint methods must conform to the specifications given in NPG 2200.2A, sections 2.6.1.4 and 2.6.2.5.

2.4 Electronic Dissemination

Although the STI Program will continue to maintain formal STI in a central repository through NASA CASI, new Agency procedures and systems are in place to support the electronic dissemination and storage of formal STI. Center publications offices can provide you with specifications for electronic versions of formal publications.

The following guidelines are provided for the release of informal STI. Informal STI, such as drafts of proposed reports or articles and collections of data or images, need not be disseminated through the previously mentioned channels. In considering electronic release of informal STI, you, your authors, and your organization are encouraged to consider several factors:

- That release of any STI requires document availability determination and prior export control approval (NPG 2200.2A, paragraph 4.2.3)
- That you and your organization have the responsibility to maintain the availability of the information and to inform users of the preliminary, or other, nature of the information
- Whether the informal STI merits the additional reviews and other steps necessary for transition to formal STI

2.5 Dissemination

The advantages of publishing and disseminating your report in the NASA STI Report Series are not only that it gains wide dissemination but also that it is archived (i.e., recorded for posterity) at the National Archives and Records Administration (NARA) through the NASA CASI. Your NASA STI is distributed to the widest practical and appropriate audience unless the information must be protected (e.g., due to national security, export control laws, trade secret,

patent, other proprietary status, or Privacy Act consideration). Before you release or distribute your NASA STI to the public, you must have a signed and approved NASA Form 1676 or your center's equivalent on file at your center (NPG 2200.2A, fig. A6-1).

Except for CR's, you may choose the type of dissemination that your document receives. Your options are given below. (For CR's, see section 2.2.3.) Contact your center publications office for more information on types of dissemination, mailing labels, and printing requirements.

2.5.1 Initial Distribution

Initial distribution is made at the time your report is first produced. You choose the distribution based on your document content and your intended readership with additional guidance from appendix A, your center's publications and export control offices, and your technical management. (For CR's, see section 2.2.3.) You may choose either standard (wider) distribution or nonstandard (more restricted) distribution, as indicated in sections 2.5.1.1 through 2.5.1.2. Indicate your preferred distribution on the document's Report Documentation Page or RDP (see appendix D) in block 12a. A copy of the RDP is available from your center publications office or from the STI Program's webpage at URL <http://sti.nasa.gov>.

Local distribution (section 2.5.1.3) is an option you may add to accompany either standard or nonstandard distribution.

2.5.1.1 Standard Distribution. Standard distribution provides the widest dissemination for your document. Copies of your report are automatically sent to NASA CASI and all NASA center libraries, to domestic and international subscribers of NASA STI, and to other government agencies responsible for public document dissemination, such as NTIS (National Technical Information Service) and GPO (Government Printing Office). GPO sends your document to the Federal depository libraries. See also section 2.2.3.

2.5.1.2 Nonstandard Distribution. Nonstandard distribution, which is a narrower dissemination, automatically provides your report to NASA center libraries and NASA CASI and to other government agencies, such as NTIS and GPO. GPO sends your document to the Federal depository libraries. See also section 2.2.3.

2.5.1.3 Local Distribution. In addition to choosing either standard or nonstandard distribution, you may add a locally originated distribution. You or your organization should provide lists or labels, as required by your center, to your center publications office. Such lists or labels may include known authors in your field, conference registrants, members of organizations or groups known to have an interest in your field, and persons who have requested similar prior papers.

For specific information about distribution requirements for your document, contact your center publications office.

2.5.2 Secondary Distribution

NASA CASI serves as the historical repository for NASA STI. Distribution of a report subsequent to its initial distribution is made by NASA CASI for a fee in print, electronic, and other nonprint media to authorized requesters on demand.

3 Other Publications Requirements

The authorizing documents and standards for this guide are listed here. If conflicting guidance is encountered, the sequence of the following list governs selection of the appropriate standard:

- NPG 2200.2A, *Guidelines for Documentation, Approval, and Dissemination of NASA Scientific and Technical Information* (ref. 2)
- NP-212, *NASA Graphics Standard— NASA Insignia* (ref. 3)
- Instructions issued by NASA centers that implement the requirements of NPG 2200.2A and NP-212
- NASA publications containing style specifications (e.g., NASA SP-7047 (ref. 1) and NASA SP-7013 (ref. 4))
- U.S. Government Printing Office *Style Manual* (ref. 5)
- Technical society or other professional style guides

3.1 Acknowledgment of Contributors

3.1.1 Authors

With the exception of NASA histories, the authorship of NASA publications is reserved for persons who perform the work from which the STI results and who can effectively defend the main technical content of the publication to a peer group.

When a publication has multiple authors, the authors' names should appear in order of their relative contribution to the reported results (that is, the first author is the chief contributor and writer, and the other names follow in order of their contribution to the work).

NASA employees may not be listed as coauthors of NASA CR's. When NASA employees contribute to rather than monitor contract or grant work, such work should be published in another series, such as NASA TM's.

3.1.2 Sources

- Credit statements or citation of source should be included for material from other publications appearing in a NASA report.
- As the author of a NASA publication, you should document your references sufficiently well so that the user is able to identify and locate the reference. (See section 4.2.4.2.)
- For copyrighted source material, you are responsible for securing written permission to reprint from the copyright holder and for including copyright acknowledgment in the manuscript on the back of the title page.

3.1.3 Sponsors

- When NASA works with or for another agency or organization, you should report your scientific and technical findings in the NASA STI Report Series and indicate joint project or sponsorship on the cover, title page, and RDP. (Such publication does not preclude the other agency or organization from publishing the work in its own series.)

- When NASA is the sponsoring agency, contractor and grantee authors must ensure that publications clearly indicate the support of NASA. In NASA CR's this is done on the cover, title page, and RDP. In non-NASA publications support is preferably acknowledged in a footnote to the publication title.
- When NASA work is sponsored or funded by one center and performed by another center, the scientific and technical findings should be reported in the NASA STI Report Series. The center performing the work is responsible for approval, production, and issuance of the technical report. Appropriate indication of the sponsorship is given on the cover, title page, and the RDP.

3.1.4 Editors and Compilers

- Recognition of editorship in cover, title, and RDP information is justified only when an editor has contributed scientific and technical expertise.
- Compilers who manage the work through the production and printing process may also be acknowledged on the cover, title page, and RDP.
- Editing and production of the report by publications personnel do not constitute scientific and technical assistance but may warrant mention in an acknowledgment section.

3.1.5 Other Contributors

Contributions by individuals other than the authors to the technical content of NASA STI should be mentioned in an acknowledgment. The contributions would include voluntary scientific or technical help received from outside NASA. When an acknowledgment is warranted in an STI series report, it appears on the back of the title page.

Normal assistance furnished by NASA personnel, however, including professional help from groups or individuals not directly related to the research, is usually not acknowledged. Supervisors or technical committees whose comments and advice result from regular work assignments are generally excluded from these acknowledgments. Credit may be given to creators of original illustrations and other research art.

3.1.6 Conference Sponsors and Editors

Conference sponsorship is indicated on the title page of any proceedings published by NASA. When NASA shares sponsorship with a noncommercial organization, the logo or seal of the cosponsor may appear on the STI Report Series cover with the NASA insignia. Use of the logo or seal of the cosponsor must be in accordance with NASA NP-212, *NASA Graphics Standard—NASA Insignia*. When warranted (see section 3.1.4), proceedings editors and their affiliations appear on the cover and title page.

3.2 Copyright

Following are general guidelines for transferring copyrights and citing copyrighted material. For more specific information, contact the NASA Headquarters Chief Intellectual Property Office or the Patent Counsel at your center.

3.2.1 Transferring Copyright

No U.S. copyright protection is available for a work produced by the U.S. Government, that is, work you produced as an employee of the U.S. Government as part of your official duties. All works authored as part of your official duties as a NASA employee must include a statement that the work is not available for U.S. copyright. For works produced by a NASA employee that are published outside the United States, NASA, as the employer, is the owner of any foreign copyright that can be asserted on the work.

- Some publishers' copyright transfer forms include a statement and signature block in which you, as the Government author, certify that the manuscript was prepared as part of your official duties. If this statement and signature block are missing, the following statement should be included either on the form or in a cover letter:

The work entitled _____ was prepared as part of my official duties as an employee of the U.S. Government and, in accordance with 17 U.S.C. 105, is not available for copyright protection in the United States.

- Copyright protection is available for work produced under contract to NASA only if authority to do so is granted in the contract. Ownership of the copyright may remain with the contractor or may be assigned to NASA within the terms of the contract.

3.2.2 Citing Copyrighted Material

- Credit should be given for material taken from non-NASA publications and included in a NASA STI report. (See also section 3.1.2.)
- For copyrighted source material, you are responsible for securing written permission to reprint from the copyright holder and for including appropriate copyright acknowledgment on the back of the title page of the report.

4 Documentation Format and Page Mechanics

The guidelines that follow are intended for use in preparing papers for the NASA STI Report Series. However, they may also be applied to NASA-authored works prepared for release through other channels. Your center publications office can provide center-specific guidelines and information about software for preparing reports.

4.1 Page Mechanics and Layout

4.1.1 Page Size

- *Standard Page Size.* The standard page size is 8 1/2 by 11 inches (with 7-1/8 by 9-3/16 inches being the maximum allowable space for text excluding page number), although other formats are produced.
- *Foldouts.* Deviation from the standard 8 1/2- by 11-inch page size of a publication, such as foldouts to present oversize charts, is sometimes necessary. Foldouts should significantly

enhance a report. Their use requires prior approval. Contact your center publications office for center-specific approval procedures.

- *Choosing Page Size.* Consult NPG 1490.5A (ref. 6) before choosing a nonstandard page size.

4.1.2 Recommendations for Font Usage

- *Font Size.* Select a type size no smaller than 10 points for text in printed copy.
- *Print Resolution.* Set a minimum of 300 dots per inch.
- *Type Style.* Choose sans serif for titles, text of figures, tables, and graphics; choose serif for text.

4.1.3 Requirements for Text Placement

A column of text may not end with a head alone, a head and only one line of text, or a short line that is not the last line of a paragraph. A column may not begin with the last line of a paragraph. A page may not end with a hyphen.

4.1.4 Page Numbering

- Use lower case roman numerals for pagination of front matter (see section 4.2.2). Reserve page i for the title page, but do not show the number on the page.
- Number main text pages sequentially throughout with arabic numerals (preferred style). If a long report has multiple sections or parts, it may be necessary to number sectionally with sets of numbers that indicate both section and page (e.g., 1-1, 4-2).
- Number back matter such as appendixes sequentially with main text (preferred style). If necessary, appendixes may be numbered separately, with the appendix designator followed by a hyphen, then the page number (e.g., A-1, A-2).
- Assign an implied page number to blank pages or pages that have a special layout which prevents the number from being shown.

4.1.5 Layout Samples and Templates

You can see samples of NASA STI report covers and title pages in appendix 4 of NPG 2200.2A (ref. 2). You can find specifications for standard front and back covers, title pages, and column formats at <http://www.sti.nasa.gov/template/layframe.htm>.

A downloadable template package is also available in several software applications. You may contact your center publications office for further resources.

Although for printed reports the standard cover and title page layouts are required, and those for text page layouts recommended, you may adapt the layouts as needed for STI produced in nonprint media. However, you must include the standard elements for both print and nonprint media.

4.2 Sections of Report

4.2.1 Covers

Use white vellum-finish cover stock. NASA SP's are not required to conform to all the following specifications for NASA STI report covers. Your center publications office can help with the design of SP covers.

4.2.1.1 Front Cover

- Standard elements:
 - Report number
 - NASA insignia (the "meatball")
 - Report title
 - Author or editor name(s) and affiliation(s)
 - Month and year of publication
 - Rule
- Other elements:
 - *Notices.* Determine if any are required on the cover to alert the reader of distribution restrictions. When required, place them at the bottom of the cover. See appendix E for sample restriction notices.
 - *Art.* Optional. If you decide to include cover art, select either one-color line art or a black-and-white photograph.
- Back of the front cover (*also called Cover 2*): NASA STI Program Profile. A copy of the Profile is included in the cover templates at <http://www.sti.nasa.gov/templates/layframe.htm>.

4.2.1.2 Back Cover. Keep the back cover blank, except for the rule at the bottom. A mailing label that includes the address, return address, and appropriate postage may be affixed to the center of the back cover.

4.2.2. Front Matter

The subsections that follow identify standard elements for pages that precede the body, or text, of a NASA STI report.

4.2.2.1 Title Page

- Standard elements for title page:
 - Report number
 - NASA insignia ("the meatball")
 - Report title
 - Author or editor name(s) and affiliation(s)
 - *Notices.* (It is optional to place the same notices on the cover as well as the title page, except for the distribution notices, such as those shown in appendix E, which must appear in both places.)

- Agency name and address
- Publication date (month and year)
- Optional elements, as applicable:
 - Contract statement and number
 - Conference information (name of the conference, location, dates, and sponsors)

4.2.2.2 Back of Title Page (p. ii). A sample of the back of a report title page showing each of the following elements is given in appendix F.

- Required element: The “Available from” statement that gives the addresses of NASA CASI and NTIS. Place these within the bottom 2 inches of the page area. Only the NASA CASI address is used for a restricted report.
- Other standard elements:
 - Acknowledgment of significant contributions directly related to the substantive content or preparation of a report by individuals other than the authors.
 - Notices. Keep notices to a minimum. Avoid using notices that call attention to unedited material or that deny the technical responsibility of the issuing office. Place notices on the back of the title page to alert the reader that a particular publication
 - a) is a presentation of preliminary findings, subject to revision as analysis proceeds
 - b) is a formal draft or working paper, intended to solicit comments and ideas from a technical peer group
 - c) uses a trademark for accurate reporting and does not intend endorsement
 - d) is a preprint

An example notice is shown below

This is a preprint of a paper intended for presentation at a conference. Because changes may be made before formal publication, this is made available with the understanding that it will not be cited or reproduced without the permission of the author.

- URL’s. If the report is available in electronic form, note on the back of the title page (just below the required “Available from” statement) and on the RDP in either block 12a (preferred) or block 11.

4.2.2.3 Optional Front-Matter Elements

- Foreword (by someone other than the author) and/or preface (by the author) (Special Publications, Conference Publications, and reference works may contain either or both.)
- Table of contents (Short reports may not need one, but longer reports do.)
- List of tables
- List of figures or illustrations

- List of acronyms, symbols, and abbreviations used in text (may alternately be placed as an appendix or after introduction in text)

4.2.3 Body

4.2.3.1 Introduction. The primary function of an introduction is to define the subject, significance, purpose, objectives, and scope of the work. The introduction may also include background information. Introductions will vary to some extent, depending on the nature of the material in the report.

4.2.3.2 Symbols List. An alphabetical-order or logical-order symbols list (with definitions and units) may directly follow the introduction or may be placed as front matter or in an appendix. If the list includes symbols from both the Latin and Greek alphabets, the symbols in the Latin alphabet precede those in the Greek. The list of subscript and superscript symbols usually follows the main symbols list, but may be included in the main list (for example, when a primary symbol and subscript or superscript are defined as a unit or when a symbol is used as both primary symbols and subscript or superscript).

4.2.3.3 Main Text. The central theme of a scientific and technical paper is developed in the main text. The overall organization of a report varies according to its subject and complexity. For example, experimental investigations contain comprehensive descriptions of specimens, apparatus, and procedures. Theoretical investigations, on the other hand, emphasize the application of new information to the state of the art. Typical report subsections are "Procedure," "Tests," "Discussion," and "Results."

4.2.3.4 Concluding Section. Most formal NASA publications have a concluding section, such as "Concluding Remarks," "Conclusions," or "Summary of Results." This section should be self-contained because many people will read it first to determine whether to read the entire report. No material that has not already been presented in another section of the report should be presented in this section.

4.2.4 Back Matter

4.2.4.1 Appendixes. Appendixes present supplementary information that might otherwise interfere with an orderly presentation of the text. You must refer to each appendix in the text and give each a title. When you use more than one appendix, identify each by a capital letter in the order mentioned in the report. Appendixes may include a list of abbreviations and acronyms used in the text. (See also sections 4.2.2.3 and 4.2.3.2.)

When an appendix is written by someone other than the author(s) of the main report, that person's name and affiliation should appear after the title of the appendix proper and after the appendix title on the table of contents page. A credit such as "With appendix [number and title] by [author]" should be placed on the report title page, in the table of contents, and in block 6 of the RDP.

4.2.4.2 References and Bibliography

- *What to Cite.* Cite all works consulted in the preparation of a paper—particularly those from which you take information—in the text where appropriate and in the reference list.

- *Responsibility for Citations.* Styling and accuracy of references are your responsibility as the author.
- *Style and Format.* Follow accepted practice in your discipline, or contact your center publications office for examples of standard basic formats.
- *References to Unpublished Information.* Unpublished sources may include pending publications, oral meeting papers, interviews, e-mail, or personal communications. Clearly identify these as such in the text of the report. Provide information that will make these sources as accessible as possible to the reader, either in a note to the text or in the reference list. Any of the citation methods used in various disciplines may be used. Always begin the reference list entry with the name of the source (person or entity), and provide as many reference citation elements as are available.
- *References to Electronic Documents.* At a time when electronic publication is on the rise, procedures and formats for citing electronic documents are still evolving. See appendix G for examples of current citation styles.
- *Limited Distribution.* In publicly available works, citing documents with limited distribution is permissible. However, the fact that a document is limited in distribution should not be mentioned in the reference citation. Place at the end of the citation the words "Available from" and the name of the organization responsible for the control and distribution of the document.

4.2.4.3 Report Documentation Page (RDP). The RDP (Standard Form 298, appendix D) is required for all reports published in the NASA STI Report Series, and is used for other types of information as determined by individual center publications offices. Directions for preparing the RDP are given on the back of the form. The information given here offers further guidance.

- *Research and Technology Objective and Plans (RTOP) Number.* Place in block 5, Funding Number.
- *Symposium Presentation Preprinted as a Technical Memorandum or Published as a Conference Publication.* Identify the symposium in block 11, Supplementary Notes.
- *Authors With Different Affiliations.* The affiliation of each author should be listed in block 11, Supplementary Notes, if they are different.
- *Subject Categories.* Required. CASI uses these categories to distribute reports to subscribers. See appendix H to select categories; then place the number of the category in block 12a, Distribution/Availability Statement.
- *Abstract.* Enter an abstract of no more than 200 words in block 13, Abstract. Compose the abstract to be informative rather than descriptive. Include the following elements:
 - Objectives of the investigation
 - Methods used (e.g., simulations, experiment, or remote sensing)
 - Results obtained
 - Conclusions reached
- *Subject Terms.* Required; provide at least three. Select from the *NASA Thesaurus* (ref. 7) and place them in block 14.

- *Classified Reports.* Ensure that all elements of the RDP are unclassified and marked as such, so that CASI may accession them. (See ref. 8, NHB 1620.3C, *NASA Security Handbook*.)
- *Placement of the RDP in the Report.* Except for NASA Special Publications, position the completed RDP as the last page of the report, facing the inside back cover. For SP's, the RDP is sent to CASI with, but not printed and bound in, the SP.

4.3 Tables and Figures

After data have been acquired, a decision must be made as to which data are to be presented in tabular (table) form and which in graphic (figure) form. Similar data should be presented in the same form throughout a report. To present detailed numerical data, use tables; for other types of information display, graphs may be more suitable.

4.3.1 Placement of Tables and Figures

- *On a Page.* Place all tables and figures as close as possible to their first citation in the text, preferably at the top or bottom of a page. It is permissible to place them before a citation, if necessary, as long as they are on the same or facing page.
- *In a Section.* Place tables and figures as close as possible to their first citation in the text unless it is necessary to group them at the end of the report.
- *At the End of a Report.* Grouping figures and tables at the end of a report is appropriate only when such placement facilitates speedy publication or when large groups of figures or tables create reading or layout problems. In these cases, place figures and tables at the back of the document, following the references.
- *In an Appendix.* If tables and figures contain only supplementary information, place them in an appendix, leaving the text to carry a discussion of the data and summary graphs.
- *Orientation.* Orient figures upright (portrait), rather than broadside (landscape, side-reading) whenever feasible.
- *Foldouts.* Avoid them if possible. Instead, rearrange and spread the figure or table horizontally across a two-page spread.
- *In Electronic Documentation.* Significantly different guidance may apply. Contact your center publications office for guidance.

4.3.2 Titles for Tables and Figures

- Never give two tables or figures the same title within the same document.
- Be as brief as possible, but also be descriptive. Include purpose and content.
- Craft titles so that readers of the table of contents can understand the nature of the illustration before they look at it. For example, instead of "Comparison," use "Cost Comparison of Two Launch Options in FY99 Dollars." Or, instead of "Graph of Results," use "Results of Performance Testing A, B, and C."

4.3.3 Tables

Preparation of useful tables requires careful attention to detail.

- *Organization.* Arrange the table so that the values are in columns topped by column labels (in the following form: concept, symbol, and unit of measure, e.g., Change, Δ , m/s) and the constants or independent variables are given in the first column. In addition, organize the first-column entries in the way that will be most helpful to the reader. Ensure structural uniformity. If column labels change in the middle of a table, the table should probably be divided into two tables.
- *Footnotes.* Use table footnotes to present information concerning special conditions relating to an entry or a class of entries. Identify each footnote by superscript italic letters. If letters are confusing, use asterisks, daggers, or other symbols.

4.3.4. Figures

Examples of figures are photographs, artwork, graphs, and drawings and diagrams.

4.3.4.1 Photographs. For compatibility, ensure that photographs of similar subjects are of similar size. Crop photos for emphasis or better composition.

4.3.4.2 Original Artwork. Provide original artwork whenever feasible: glossy, continuous-tone (not screened) prints or photographs; original drawings; or first-off prints (hard copy) of electronic art. Electronic files may be incorporated into a report as long as they are of suitable resolution. See your center's publications and graphics offices for advice.

4.3.4.3 Graphs

- *Consistency.* For easy comparison by the reader, present similar data in the same type of graph drawn to the same scale, using the same symbology throughout the report.
- *Lines.* Make them as simple as possible. It is advisable to have no more than six types of lines and data points on a graph; it is better to have only four. The lines and data points should refer to the same condition in related figures.
- *Scale.* Ordinate and abscissa scales and proportions should be the same on similar figures (thus allowing overlays).

4.3.4.4 Drawings and Diagrams

- *Labels.* Place labels directly on a drawing to designate or describe elements of that drawing. Capitalize the first word of the label. When space is very limited, use letters or numbers rather than words, arranging them in some spatial order (for example, clockwise around the drawing). Identify these letters or numbers in a key.
- *Leaders.* Leaders from a label to an item in a figure go from the beginning of the first word (if it is from the left of the label) and from the end of the last word (if it is from the right of the label). Arrowheads are not used on leaders, only on dimension lines.
- *Shading.* When it is necessary to differentiate parts of a drawing, use shading rather than color. It is also acceptable to use spaced black dots or lines for this purpose.

4.3.4.5 Text in Figures. You can facilitate page makeup by following certain procedures during the early stages of producing your report. When you prepare figures

- Limit the text in figures to letters, numbers, symbols, words, and short phrases.
- Identify the letters, numbers, and symbols in a key or legend.
- Provide details and explanations in the body of the document where the figure is discussed.
- Place equations in the body of the document.
- Display tabular material in a separate table.

4.3.4.6 Use of Color. Although there are no restrictions on the use of color for documents posted on the web, NASA has limitations on the use of color in printed documents. The use of color increases preparation and printing costs and may delay the publication date. Color is used in printed STI Report Series documents only when necessary to convey scientific and technical material clearly and unambiguously. If there is some chance that a color visual will be printed in black and white, try to avoid setting light blues and yellows against white, or red against black. The use of color must be justified and authorized on a case-by-case basis using center-specific procedures. For further assistance, contact your center publications office or printing officer. (See also NPG 2200.2A, section 2.5.2 (ref. 2), and NPG 1490.5A (ref. 6).)

5 Special Preparation Concerns

Attention to editorial details such as clear, concise sentences and paragraphs, well-constructed headings and outlines, and consistent use of abbreviations and symbols increases reader confidence in your work. Whether or not you choose to use the editorial expertise provided by your center publications office, following a style guide can improve your writing. In addition to the information in this guide and your center publications office's guides, the following publications are recommended for use in preparing NASA STI reports. The style guides published for specific scientific and technical disciplines are also acceptable for use in NASA STI reports and other papers by NASA authors.

- McCaskill, Mary K.: *Grammar, Punctuation, and Capitalization—A Handbook for Technical Writers and Editors*. NASA SP-7084, 1990 (ref. 9)
- American National Standards Institute: *Scientific and Technical Reports—Elements, Organization, and Design*. ANSI-NISO Z39.18-1995, 1995 (ref. 10)
- Swanson, Ellen: *Mathematics Into Type: Copyediting and Proofreading of Mathematics for Editorial Assistants and Authors*. American Mathematical Society, 1979, 1986 (ref. 11)

5.1 Titles and Headings

Titles should

- Convey maximum information as succinctly as possible
- Involve careful word selection because much indexing and abstracting is based only on the title

Headings should

- Be brief and descriptive

- Not contain verbs
- Be numbered only when cross-referencing is needed
- Be paired with at least one other heading under the same order level heading
- Be ranked in no more than three levels or sublevels, unless the publication is long or complex

5.2 Cross-References

Be sure to check cross-references in the following items each time your manuscript is revised. Inattention to these details can cause errors and reduce the confidence of the reader in your conclusions.

- Text
- Figures
- Tables
- Symbols list
- Glossary (not in most papers—normally included in symbols)
- Appendixes
- Index
- Table of Contents

5.3 Trade Names and Trademarks

A trade name, or commercial name, is any name used by a person to identify his or her business or vocation. Generally, these names are not registered. A trademark is a word or symbol that is used to identify a particular product or service in a way that distinguishes it from other similar products or services. A trademark may be registered.

Use generic names whenever possible and avoid using trade names or trademarks because it is improper to advertise, endorse, or criticize commercial products or services in NASA publications. If use of a trade name or trademark is the only way to specify material or equipment that is necessary to reproduce the results, follow these guidelines:

- Use trademarks only as a proper adjective (i.e., capitalized and modifying the generic term); on their first appearance in the text, accompany the trademark with the name of its registered owner.
- State in a disclaimer that trade names or trademarks are used in the report for identification only and that this usage does not constitute an official endorsement, either expressed or implied, by NASA. Place this disclaimer on the back of the title page of NASA STI reports or as a footnote to other documents (such as journal articles and conference proceedings) with information concerning the trademark or trade name.
- Never compare commercial products; present the data and let the reader make the comparison.

5.4 Spacecraft Designations

- Piloted spacecraft are always designated with arabic numerals before and after launch (e.g., Apollo 17).
- Unpiloted spacecraft are designated with capital letters before launch and arabic numerals after successful launch.
- Rockets and launch vehicles are designated by name and roman numeral, including stages of multicomponent vehicles (e.g., Saturn V, S-IVB stage, and Delta III).

5.5 Abbreviations

- Abbreviate units of measure after numbers.
- Follow the U.S. GPO *Style Manual* (ref. 5) for standard forms of U.S. Customary Units.
- When using SI units, follow the International System of Units conventions.
- Remember that singular and plural units carry the same abbreviation (e.g., 1 in. and 3 in.).
- Introduce other abbreviations and acronyms in parentheses after the first use of the complete term to avoid repetition and conserve space (e.g., root mean square (rms)).
- Include an abbreviation, symbols, or acronym list in the front or back matter of the report to avoid repetition and conserve space.
- In reference lists, use abbreviations for source material cited after the title.
- Abbreviate periodicals and meeting titles according to style sources, such as the American Chemical Society's *CASSI* (ref. 12) and the *Abbreviations Dictionary* (ref. 13).

5.6 Numerals

- Use numerals at all times with units of measure; use numerals for values 10 and greater when used without units.
- Separate numbers of more than four into groups of three from the decimal point. A small (or thin) space is the preferred separator, in compliance with recommended international practice for scientific and technical documents, though a comma is sometimes used.
- Close up four-digit numbers unless they are in aligned columns with numbers of five or more digits.

5.7 Mathematical Presentation

For a better quality publication, we recommend the following:

- Use the standard symbols established in your discipline.
- Define the symbols at the time of their first appearance in a document.
- Include an alphabetical symbols list in the document where appropriate (in front matter, after the introduction, or in the appendix).
- Close up numbers and letter symbols in expressions and equations; however, leave a space before and after mathematical functions (such as "sin" and "lim") and mathematical signs of

operation (such as +, −, and ×); before differentials d and after their arguments; after the arguments of trigonometric and logarithmic terms; and before and after functional notation.

- Number equations in the main text continuously as (1), (2), (3),....
- Number equations in appendixes by either continuing the numbering of the main text or by restarting the numbering in each appendix as (A1), (A2), (B1), (B2).
- Use the same number for any repeated equation.
- Use identifiers such as (1a) or (C3a) for equivalent or derivative equations.
- Use a brace to connect groups of equations with the same number.
- Place equation numbers at the right margin, leaving space between the equation and the number; if there is not enough room for the number on the line with the equation, place it on the line below the equation.
- Refer to equations in text as equation (6) or (eq. (6)).

5.8 International System of Units

The International System of Units (SI) is the preferred system of weights and measures for NASA as stated in NPD 8010.2B, *Use of the Metric System of Measurement in NASA Programs* (ref. 14).

- If you performed your scientific and technical activities using the metric system, document or report your findings using SI units.
- If you performed your scientific and technical activities using inch-pound measurements, document or report your findings using U.S. customary units.
- If you need additional information on SI units, symbols, prefixes, and usage in documentation in both the U.S. and in the international business community, refer to Artusa, Elisa A. *SI (Metric) Handbook*, NASA TM-109197 (ref. 15).

5.9 Proofreading

We recommend that you

- Proofread your publication for accuracy and consistent quality
- Proofread after each revision cycle

5.10 Checklists, Questions, and Other Information

Checklists are included as appendixes B and C to assist you with the details of the publication process. Frequently asked questions and the answers are found in appendix I. Definitions and acronyms are given in appendix J.

Appendix A

Types of NASA STI Publications, Related STI Report Series, and Suggested Distribution

Manuscript Contents	Appropriate Series	Appropriate Initial Distribution
Article for a professional journal	None required; TP for expanded treatment and TM for preprint	2 copies to CASI (15 if the article contains color or is a size other than 8.5 by 11 inches)
Article for a technical magazine	None required; TP for expanded treatment and TM for preprint	2 copies to CASI (15 if the article contains color or is a size other than 8.5 by 11 inches)
Atlas of scientific imagery	TP or SP	Standard
Bibliography:		
Continuing	SP	Standard
Extensive annotation	TP	Standard
Minimal annotation	TM	Standard or Nonstandard
Contractor or grantee results and findings	CR, TP, or SP	Standard or Nonstandard
Critical review of the literature	TP	Standard
Critical tables	TP	Standard
Data compilation:		
Extensive use	TP	Standard
Limited use	TM	Nonstandard
Design standards	TP	Standard
Dissertation or thesis by employee, relating to work	TM	Standard or Nonstandard
Engineering report	TP	Standard
Handbook	TP	Standard
History	SP	Standard
Letter (e.g., for a professional journal)	None required	2 copies to CASI (15 if the report contains color or is a size other than 8.5 by 11 inches)
Limited distribution report	TP or TM	Standard or Nonstandard
Literature survey, review	TP	Standard
Management report	SP (6000 series)	Nonstandard
Manual	TP or TM	Standard or Nonstandard
Monograph	TP	Standard
Preliminary results report	TM	Nonstandard
Preprint of paper for a professional meeting	TM	Standard or Nonstandard
Proceedings of a workshop, conference, seminar, etc.	CP	Standard
Program description or summary	SP	Standard
Report to another agency	TM	Standard or Nonstandard
Research report	TP	Standard
Review paper	TP	Standard
Security-classified report	TP or TM	2 copies of the unclassified RDP to CASI
Sponsored research report:		
NASA sponsor	CR	Standard or Nonstandard
Non-NASA sponsor	TM	Standard or Nonstandard
State-of-the-art review	TP	Standard
Technical report, complete and comprehensive	TP	Standard
Textbook, scientific or technical	TP	Standard
Translation	TT	2 copies to CASI (15 if the translation contains color or is a size other than 8.5 by 11 inches)
Working paper (external circulation)	TM	Nonstandard

Appendix B

Author Checklist To Publish Documents in the NASA STI Report Series

_____ Determine if the NASA STI Report Series is appropriate for your needs (NASA SP-7602, section 2.5, and URL <http://www.sti.nasa.gov/>)

_____ Determine with your center's technical management and publications office the appropriate report type and the level of technical review (appendix A and section 2.2 of NASA SP-7602)

_____ Contact your center's publications and printing offices to determine the following:

- What production/publishing services are available, turnaround times, and costs.
- If your center has center-specific templates (Agency templates are available at URL <http://www.sti.nasa.gov/template/layfram2.htm>).
- What printing requirements or restrictions exist (time necessary to print, use of color, number of copies, distribution selections, and required approvals). NASA reports are printed through the Government Printing Office.
- What type of electronic file is required and what approvals are needed to add your document to your center's Technical Report Server (<http://techreports.larc.nasa.gov/cgi-bin/ntrs>).
- Tips on how to complete NASA Form (NF) 1676 (Scientific and Technical Document Availability Authorization (DAA)) or your center's version of this form. This is an Agency requirement in order to release STI in any media.
- Advice on how to complete SF (Standard Form) 298 (Report Documentation Page), which is the last page of your document. This form facilitates correct indexing into the worldwide STI Database and accurate subsequent dissemination.

_____ Complete the draft of your document

_____ Complete SF 298 and add it as the last page of your document or have your publications office do this. If your document is a NASA Special Publication (SP), complete SF 298 and send it with your document but do not include it as the last page

_____ Have appropriate technical personnel review and approve your document (see section 2.2 of NASA SP-7602). See appendix C for information on items to check prior to publication

_____ Revise document, if necessary, and produce final document

_____ Send your document through your center's appropriate channels (appropriate channels are defined by NASA Form 1676 or your center's equivalent); you may not publish STI in any format unless this form is approved and on file at your center

_____ Send to center's publications or printing office

_____ Request that your document be added to your center's Technical Report Server, if appropriate (if your document is unlimited and unclassified)

_____ We recommend that you coordinate publication with your center's publications office; however, if you do not do so, send a copy of your document, with the SF 298 and a copy of the approved NF 1676, to the following:

Attention: Acquisitions
NASA Center for AeroSpace Information
7121 Standard Drive
Hanover, Maryland 21076-1320
(301) 621-0390

Appendix C

Publications Review Checklist

The following items should be checked before release of your document. Contact your publications office to see what services are available to assist you.

- _____ Report is written clearly.
- _____ All numbered or lettered items (figures, tables, equations, references, and appendixes) are introduced in correct order.
- _____ All numbered or lettered items are numbered or lettered correctly and referred to accurately.
- _____ No incorrectly or inconsistently spelled words or obvious grammar or punctuation errors exist.
- _____ No statements that will embarrass NASA or the Federal Government are included.
- _____ Any conclusions presented are supported by the text.
- _____ References cited are available with sufficient information to identify correct document.
- _____ Graphic and tabular data are clearly presented and are consistent.
- _____ Report complies with policies for restricted, proprietary, or classified information.
- _____ Appropriate technical review has been done.
- _____ Appropriate release review requirements have been done. (Contact your center publications office to find out what the specific requirements are.)

Appendix D

Report Documentation Page

REPORT DOCUMENTATION PAGE			Form Approved GSA No. 0704-0190	
<p>Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0190), Washington, DC 20503.</p>				
1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE July 1998	3. REPORT TYPE AND DATES COVERED Technical Publication		
4. TITLE AND SUBTITLE Flight Evaluation of Center TRACON Automation System Trajectory Prediction Process		5. FUNDING NUMBERS WU 538-04-11-16		
6. AUTHOR(S) David H. Williams and Steven M. Green				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) NASA Langley Research Center Hampton, VA 23681-2199		8. PERFORMING ORGANIZATION REPORT NUMBER L 17644		
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) National Aeronautics and Space Administration Washington, DC 20546-0001		10. SPONSORING/MONITORING AGENCY REPORT NUMBER NASA/TP 1998-208149		
11. SUPPLEMENTARY NOTES David H. Williams: Langley Research Center, Hampton, VA; Steven M. Green: Ames Research Center, Moffett Field, CA				
12a. DISTRIBUTION AVAILABILITY STATEMENT Unclassified Unlimited Subject Category: 04 Distribution: Standard Availability: NASA CASI (301) 621-0390		12b. DISTRIBUTION CODE		
13. ABSTRACT (Maximum 200 words) Two flight experiments (Phase I in October 1992 and Phase II in September 1994) were conducted to evaluate the accuracy of the Center TRACON Automation System (CTAS) trajectory prediction process. The Transport Systems Research Vehicle (TSRV) Boeing 737 based at Langley Research Center flew 57 arrival trajectories that included cruise and descent segments; at the same time, descent clearance advisories from CTAS were followed. Actual trajectories of the airplane were compared with the trajectories predicted by the CTAS trajectory synthesis algorithms and airplane Flight Management System (FMS). Trajectory prediction accuracy was evaluated over several levels of cockpit automation that ranged from a conventional cockpit to performance based FMS vertical navigation (VNAV). Error sources and their magnitudes were identified and measured from the flight data. The major source of error during these tests was found to be the predicted winds aloft used by CTAS. The most significant effect related to flight guidance was the cross track and turn overshoot errors associated with conventional VOR guidance. FMS lateral navigation (LNAV) guidance significantly reduced both the cross track and turn overshoot error. Pilot procedures and VNAV guidance were found to significantly reduce the vertical profile errors associated with atmospheric and airplane performance model errors.				
14. SUBJECT TERMS CTAS, FMS, Trajectory prediction, Flight management, Air traffic control		15. NUMBER OF PAGES 88		
		16. PRICE CODE A05		
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT U1	

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

Appendix E

Restriction Notices

International Traffic in Arms Regulations (ITAR) Notice

This document contains information which falls under the purview of the U.S. Munitions List (USML), as defined in the International Traffic in Arms Regulations (ITAR), 22 CFR 120-130, and is export controlled. It shall not be transferred to foreign nationals in the U.S. or abroad, without specific approval of a knowledgeable NASA export control official, and/or unless an export license/license exemption is obtained/available from the United States Department of State. Violations of these regulations are punishable by fine, imprisonment, or both.

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Appendix F

Back of NASA STI Report Title Page

Acknowledgments

The authors acknowledge the assistance of those individuals who aided in the preparation of this document. William James was instrumental in obtaining source data, J.D. DeMarcos edited and critiqued the text, Doris Bailey typed the manuscripts, the staffs of the NASA Headquarters Library and the Scientific and Technical Information Program provided assistance in locating bibliographic references, and the NASA Headquarters Printing and Graphics office developed the layout and handled printing.

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Available from:

NASA Center for AeroSpace Information (CASI)
7121 Standard Drive
Hanover, MD 21076-1320
(301) 621-0390

National Technical Information Service (NTIS)
5285 Port Royal Road
Springfield, VA 22161-2171
(703) 605-6000

This report is also available in electronic form at URL <http://www.sti.nasa.gov/>.

Appendix G

References to Electronic Documents in NASA STI Reports

Citations of electronic documents appear in the "References" section of the report along with citations of paper documents. The citation should include

- Name of author
- Title of document
- Title of main document, if applicable
- Electronic address
- Date document was written or posted, if available
- Revision number, if applicable
- Paragraph numbers, if applicable
- Date of accession

Electronic documents can be revised or become inaccessible without warning. You are encouraged to save a copy of the referenced document either on paper or electronically on disk.

When printing electronic addresses in citations, ensure that extra punctuation or characters are not included in the address and all characters of the address are included. If it becomes necessary to break an electronic address because of available line space, a hyphen should not be used. The additional hyphen could be mistaken for a character in the address. Electronic addresses should be broken after slashes, dots, or colons. Avoid placing an electronic address at the end of a sentence. Restructure the sentence to set off the address as you would an equation.

In addition, both formal and informal documents are published electronically. Formal documents include scholarly information such as NASA formal reports. Informal documents include e-mail and discussions groups. Because such documents are difficult, if not impossible, to access, reference to informal documents is discouraged. If the information must be referenced, it should be treated similar to an informal personal communication in paper documents. Clearly identify the reference as such and place the following identification in a parenthetical note in the reference list, with an appropriate notation: "unpublished," "to be published," or "personal communication." Personal communications should include name and affiliation of person doing the communicating.

The following references are cited in the suggested style. Information in quotation marks should be italicized. Some line returns are forced to illustrate concepts for breaking lines.

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Appendix H

NASA STI Database Subject Divisions and Categories

This table lists the subject divisions and categories used to catalog NASA STI reports before they are processed and entered in the NASA STI Database.

AERONAUTICS

- 01 Aeronautics
- 02 Aerodynamics
- 03 Air Transportation and Safety
- 04 Aircraft Communications and Navigation
- 05 Aircraft Design, Testing and Performance
- 06 Aircraft Instrumentation
- 07 Aircraft Propulsion and Power
- 08 Aircraft Stability and Control
- 09 Research and Support Facilities (Air)

ASTRONAUTICS

- 12 Astronautics (General)
- 13 Astrodynamics
- 14 Ground Support Systems and Facilities (Air)
- 15 Launch Vehicles and Space Vehicles
- 16 Space Transportation
- 17 Space Communications, Spacecraft Communications, Command and Tracking
- 18 Spacecraft Design, Testing and Performance
- 19 Spacecraft Instrumentation
- 20 Spacecraft Propulsion and Power

CHEMISTRY AND MATERIALS

- 23 Chemistry and Materials (General)
- 24 Composite Materials
- 25 Inorganic and Physical Chemistry
- 26 Metallic Materials
- 27 Nonmetallic Materials
- 28 Propellants and Fuels
- 29 Materials Processing

ENGINEERING

- 31 Engineering (General)
- 32 Communications and Radar
- 33 Electronics and Electrical Engineering
- 34 Fluid Mechanics and Heat Transfer
- 35 Instrumentation and Photography
- 36 Lasers and Masers
- 37 Mechanical Engineering
- 38 Quality Assurance and Reliability
- 39 Structural Mechanics

GEOSCIENCES

- 42 Geosciences (General)
- 43 Earth Resources and Remote Sensing
- 44 Energy Production and Conversion
- 45 Environment Pollution
- 46 Geophysics
- 47 Meteorology and Climatology
- 48 Oceanography

LIFE SCIENCES

- 51 Life Sciences (General)
- 52 AeroSpace Medicine
- 53 Behavioral Sciences
- 54 Man/System Technology and Life Support
- 55 Space Biology

MATHEMATICAL AND COMPUTER SCIENCES

- 59 Mathematical and Computer Sciences (General)
- 60 Computer Operations and Hardware
- 61 Computer Programming and Software
- 62 Computer Systems
- 63 Cybernetics
- 64 Numerical Analysis
- 65 Statistics and Probability
- 66 Systems Analysis
- 67 Theoretical Mathematics

PHYSICS

- 70 Physics (General)
- 71 Acoustics
- 72 Atomic and Molecular Physics
- 73 Nuclear and High Energy Physics
- 74 Optics
- 75 Plasma Physics
- 76 Solid State Physics
- 77 Thermodynamics and Statistical Physics

SOCIAL SCIENCES

- 80 Social Sciences (General)
- 81 Administration and Management
- 82 Documentation and Information Science
- 83 Economics and Cost Analysis
- 84 Law, Political Science, and Space Policy
- 85 Urban Technology and Transportation

SPACE SCIENCES

- 88 Space Sciences (General)
- 89 Astronomy
- 90 Astrophysics
- 91 Lunar and Planetary Exploration
- 92 Solar Physics
- 93 Space Radiation

GENERAL

- 99 General

Appendix I

Frequently Asked Questions (FAQ's)

Q: If I have a question that isn't covered in this document, what other sources of information are there?

A: For more information about the NASA Scientific and Technical Information (STI) Program Office and NASA publications, you can contact any of the following sources:

- Access the NASA STI Program Home Page at <http://www.sti.nasa.gov/>
- E-mail your question via the Internet to help@sti.nasa.gov
- Fax your question to the NASA STI Help Desk at (301) 621-0134
- Telephone the NASA STI Help Desk at (301) 621-0390
- Write to:

NASA STI Help Desk
NASA Center for AeroSpace Information
7121 Standard Drive
Hanover, MD 21076-1320

Q: I've been invited to give a talk at a scientific conference on my research findings. Should I publish my presentation?

A: Yes. Oral presentations of scientific and technical findings are one way to ensure the timely dissemination of information to audiences at society meetings and other professional gatherings. NASA and NASA-sponsored authors who take this approach should distribute copies of the presentation to attendees and publish their presentation in the appropriate NASA STI Report Series, if appropriate, to include their work in the NASA STI Database.

Q: What approvals are required to publish my findings through a foreign publisher or distribute my document to a foreign audience?

A: Export control review and approval to release STI are required for domestic and foreign publishing. Complete, have approved, and have your center maintain your file copy of NASA Form 1676, "NASA Scientific and Technical Document Availability Authorization (DAA)" or your center's equivalent to this form prior to release to any audience. Contact your center's publication and export control office for more information.

Q: What is an "external publication"?

A: An external publication is defined as a technical paper, article, or book reporting on NASA research submitted by a NASA employee, contractor, or grantee for publication through a non-NASA channel.

Q: The terms "informal" and "formal" STI are used. What's the difference?

A: Formal STI is intended for release in the NASA STI Report Series (e.g., Technical Memorandum, Conference Publication) or as a professional journal article or presentation

for which the NASA STI Program maintains responsibility for dissemination and preservation. Informal STI is not intended for initial release in the NASA STI Report Series.

Q: How is the NASA STI Report Series defined?

A: There are discrete report designations that characterize NASA and NASA Contractor STI reports. These series include Technical Publication (TP), Technical Memorandum (TM), Contractor Report (CR), Conference Publication (CP), Special Publication (SP), and Technical Translation (TT).

Q: Please clarify the roles of a "technical monitor."

A: A technical monitor is the NASA employee appointed to monitor or manage technical progress, referred to in grant instructions as the technical officer. In contract instructions, this employee may be identified as the project manager or the contracting officer's technical representative (COTR).

Q: What is the basis for selecting a suitable series category for a NASA publication and who decides?

A: Selection of the correct series in which a document is published should be based on the content of your manuscript and the needs of an identifiable readership. Make the preliminary determination in conjunction with the NASA STI Lead Center or your center publications office. It is subject to approval as part of the NASA Headquarters Office or the originating center's review process.

Q: What approvals are required to release STI in hard copy or via the Internet?

A: You must have an approved copy on file of NASA Form 1676 or your center-specific version of this form to release STI in any media.

Q: I need to use color in my document. What approvals are required?

A: First consider how your document will be disseminated. Color is useful if you will disseminate via the Internet; however, remember that readers may print to black and white printers. For hard (paper) copies, Government-wide restrictions exist on the use of color because color increases the cost of printing, so discuss your options and restrictions with your center's publications and printing offices early in your planning process.

Q: What is the best format source for creating an STI document?

A: Templates of typical STI reports are available from the STI homepage at URL <http://www.sti.nasa.gov/>. These include suggested typefaces, font sizes, standard covers, title pages, and interior column formats for publications released in the NASA STI Report series.

Appendix J

Acronyms and Definitions

Acronyms:

ANSI	American National Standards Institute
BXA	Bureau of Export Administration
CASI	Center for AeroSpace Information
CFR	Code of Federal Register
COTR	Contracting Officer's Technical Representative
CP	Conference Publication
CR	Contractor Report
DAA	NASA Form 1676, NASA Scientific and Technical Availability Authorization: Document Availability Authorization
EAR	Export Administration Regulations
GPO	Government Printing Office
ITAR	International Traffic in Arms Regulations
NASA	National Aeronautics and Space Administration
NF	NASA Form
NHB	NASA Handbook
NP	NASA Publication (nontechnical, general information that is not part of the STI series)
NPD	NASA Policy Directive
NPG	NASA Procedures and Guidelines
NTIS	National Technical Information Service
PDF	Portable Document Format
PS	Postscript
RDP	Report Documentation Page
RTOP	Research and Technology Objective and Plans
SBIR	Small Business Innovation Research
SF	Standard Form
SGML	Standard Generalized Markup Language
SI	International System of Units
SP	Special Publication
STI	Scientific and Technical Information
TIFF	Tagged Image File Format
TM	Technical Memorandum
TP	Technical Publication
TRS	Technical Report Server
TT	Technical Translation
URL	Uniform Resource Locator
USML	U.S. Munitions List

Definitions:

dpi dots per inch. The manner in which the resolution (sharpness and clarity) of a printer or scanner is measured. For example, if a printer has a resolution of 300 dpi, that means that in 1 in., there are 300 dots in a row across and 300 dots in a row down. The more dots per inch, the smaller each dot has to be, and the smoother the printed image will appear to be.

Front matter written material preceding the main text of a book or report; examples of front matter are table of contents, preface, and foreword.

Rule a line or bar (1/4 in. for the NASA cover) added to a page for emphasis or decoration; also a thin line either vertical or horizontal, often used to separate parts of a table or columns of text.

Sans serif a category of type that has no serifs. Serifs are the tiny crossbars on the ends of the strokes on letters in some type designs. An example of sans serif type is Helvetica.

Serif a category of type that has serifs. Examples of serif types are Times Roman and Garamond. Research indicates that serif fonts are more readable.

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